^{40}Ar/^{39}Ar Geochronology Results for the Gooseberry Creek, Haycock Mountain, Mercur, Stockton, and Tabbys Peak Quadrangles, Utah

by

Utah Geological Survey and
Nevada Isotope Geochronology Laboratory

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Utah Department of Natural Resources
2012

INTRODUCTION

This open-file report makes available raw analytical data from laboratory procedures completed to determine the age of rock samples collected during geologic investigations funded or partially supported by the Utah Geological Survey (UGS). The references listed in table 1 generally provide additional information such as sample location, geologic setting, and significance or interpretation of the samples in the context of the area where they were collected. This report was prepared by the Nevada Isotope Geochronology Laboratory (NIGL) under contract to the UGS. These data are highly technical in nature and proper interpretation requires considerable training in the applicable geochronologic techniques.

Table 1. Sample numbers and locations.

Sample #	7.5' quadrangle	UTM Easting NAD27	UTM Northing NAD27	Reference
D-48	Tabbys Peak	0332246	4476004	Clark and others, in review; Clark and others, in prep.
RV-24	Mercur	0396473	4462674	Clark and others, in review
RV-30	Stockton	0387157	4478428	Clark and others, in review
		Latitude (N) NAD27	**Longitude (W) NAD27**	
GC110309-2	Gooseberry Creek	38.754^{o}	111.680^{o}	Doelling and Kuehne, in prep.
HM071809-2	Haycock Mountain	37.70590^{o}	112.55220^{o}	Biek and others, in prep.
HM071809-4	Haycock Mountain	37.70661^{o}	112.55019^{o}	Biek and others, in prep.

DISCLAIMER

REFERENCES

Biek, R.F., and others, in preparation, Interim geologic map of the Panguitch 30' x 60' quadrangle, Garfield, Iron, and Kane Counties, Utah: Utah Geological Survey Open-File Report, scale 1:62,500.

Clark, D.L., Kirby, S.M., and Oviatt, C.G., in review, Interim geologic map of the Rush Valley 30' x 60' quadrangle, Tooele, Utah, Salt Lake, and Juab Counties, Utah: Utah Geological Survey Open-File Report, scale 1:62,500.

Clark, D.L., Oviatt, C.G., and Page, D., in preparation, Geologic map of Dugway Proving Ground and adjacent areas, parts of the Wildcat Mountain, Rush Valley, and Fish Springs 30' x 60' quadrangles, Tooele County, Utah: Utah Geological Survey Map, scale 1:75,000.

Doelling, H.H., and Kuehne, P.A., in preparation, Interim geologic map of the Gooseberry Creek quadrangle, Sevier County, Utah: Utah Geological Survey Open-File Report, scale 1:24,000.

The Nevada Isotope Geochronology Laboratory

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LABORATORY DESCRIPTION AND PROCEDURES

Samples analyzed by the $^{40}Ar/^{39}Ar$ method at the University of Nevada Las Vegas were wrapped in Al foil and stacked in 6 mm inside diameter sealed fused silica tubes. Individual packets averaged 3 mm thick and neutron fluence monitors (FC-2, Fish Canyon Tuff sanidine) were placed every 5-10 mm along the tube. Synthetic K-glass and optical grade CaF_2 were included in the irradiation packages to monitor neutron induced argon interferences from K and Ca. Loaded tubes were packed in an Al container for irradiation. Samples irradiated at the U. S. Geological Survey TRIGA Reactor, Denver, CO were in-core for 28 hours in the In-Core Irradiation Tube (ICIT) of the 1 MW TRIGA type reactor. Correction factors for interfering neutron reactions on K and Ca were determined by repeated analysis of K-glass and CaF_2 fragments. Measured $(^{40}Ar/^{39}Ar)_K$ values were 6.42 (± 24.60%) x 10^{-3}. Ca correction factors were $(^{36}Ar/^{37}Ar)_{Ca}$ = 2.57 (± 3.19%) x 10^{-4} and $(^{39}Ar/^{37}Ar)_{Ca}$ = 6.50 (± 1.42%) x 10^{-4}. J factors were determined by fusion of 4-8 individual crystals of neutron fluence monitors which gave reproducibility's of 0.02% to 0.46 at each standard position. Variation in neutron fluence along the 100 mm length of the irradiation tubes was <4%. Matlab curve fit was used to determine J and uncertainty in J at each standard position. No significant neutron fluence gradients were present within individual packets of crystals as indicated by the excellent reproducibility of the single crystal fluence monitor fusions.

Irradiated FC-2 sanidine standards together with CaF_2 and K-glass fragments were placed in a Cu sample tray in a high vacuum extraction line and were fused using a 20 W CO_2 laser. Sample viewing during laser fusion was by a video camera system and positioning was via a motorized sample stage. Samples analyzed by the furnace step heating method utilized a double vacuum resistance furnace similar to the Staudacher et al. (1978) design. Reactive gases were removed by three GP-50 SAES getters prior to being admitted to a MAP 215-50 mass spectrometer by expansion. The relative volumes of the extraction line and mass spectrometer allow 80% of the gas to be admitted to the mass spectrometer for laser fusion analyses and 76% for furnace heating analyses. Peak intensities were measured using a Balzers electron multiplier by peak hopping through 7 cycles; initial peak heights were determined by linear regression to the time of gas admission. Mass spectrometer discrimination and sensitivity was monitored by repeated analysis of atmospheric argon aliquots from an on-line pipette system. Measured $^{40}Ar/^{36}Ar$ ratios were 282.56 ± 0.55% during this work, thus a discrimination correction of 1.0458 (4 AMU) was applied to measured isotope ratios. The sensitivity of the mass spectrometer was ~6 x 10^{-17} mol mV^{-1} with the multiplier operated at a gain of 36 over the Faraday. Line blanks averaged 3.05 mV for mass 40 and 0.02 mV for mass 36 for laser fusion analyses and 3.82 mV for mass 40 and 0.02 mV for mass 36 for furnace heating analyses. Discrimination, sensitivity, and blanks were relatively constant over the period of data collection. Computer automated operation of the sample stage, laser, extraction line and mass spectrometer as well as final data reduction and age calculations were done using LabSPEC software written by B. Idleman (Lehigh University). An age of 28.02 Ma (Renne et al., 1998) was used for the Fish Canyon Tuff sanidine fluence monitor in calculating ages for samples.

For $^{40}Ar/^{39}Ar$ analyses a plateau segment consists of 3 or more contiguous gas fractions having analytically indistinguishable ages (i.e. all plateau steps overlap in age at

± 2σ analytical error) and comprising a significant portion of the total gas released (typically >50%). Total gas (integrated) ages are calculated by weighting by the amount of ^{39}Ar released, whereas plateau ages are weighted by the inverse of the variance. For each sample inverse isochron diagrams are examined to check for the effects of excess argon. Reliable isochrons are based on the MSWD criteria of Wendt and Carl (1991) and, as for plateaus, must comprise contiguous steps and a significant fraction of the total gas released. All analytical data are reported at the confidence level of 1σ (standard deviation).

Note: Check your samples data sheets for the discrimination, and fluence monitor values used for each sample.

RESULTS

General Comments

Your samples were run as conventional furnace step heating analyses on bulk groundmass or biotite separates, as well as single crystal laser fusion analyses on sanidine. All data are reported at the 1σ uncertainty level, unless noted otherwise.

Furnace step heating analyses produce what is referred to as an apparent age spectrum. The "apparent" derives from the fact that ages on an age spectrum plot are calculated assuming that the non-radiogenic argon (often referred to as trapped, or initial argon) is atmospheric in isotopic composition ($^{40}Ar/^{36}Ar = 295.5$). If there is excess argon in the sample ($^{40}Ar/^{36}Ar > 295.5$) then these apparent ages will be older than the actual age of the sample. U-shaped age spectra are commonly associated with excess argon (the first few and final few steps often have lower radiogenic yields, thus apparent ages calculated for these steps are effected more by any excess argon present). Excess argon can also produce generally discordant age spectra. This is often verified by isochron analysis, which utilizes the analytical data generated during the step heating run, but makes no assumption regarding the composition of the non-radiogenic argon. Thus, isochrons can verify (or rule out) excess argon, and isochron ages are usually preferred if a statistically valid regression is obtained (as evidenced by the MSWD, mean square of weighted deviates, a measure of the coherence of the population). If such a sample yields no reliable isochron, the best estimate of the age is that the minimum on the age spectrum is a maximum age for the sample (it could be affected by excess argon, the extent depending on the radiogenic yield). $^{40}Ar/^{39}Ar$ total gas ages are equivalent to K/Ar ages. Plateau ages are sometimes found, these are simply a segment of the age spectrum which consists of 3 or more steps, comprising >50% of the total gas released, which overlap in age at the ±2σ analytical error level (not including the J-factor error, which is common to all steps). However, in general an isochron age is the best estimate of the age of a sample, even if a plateau age is obtained.

Laser fusion analyses allow the identification of juvenile phenocryst populations (which should yield the eruption age) as well as any older contaminating xenocrysts, or younger altered crystals. Data sets are screened for anomalous older (or younger) outliers by standard statistical methods. A weighted mean is calculated, and the MSWD is checked. Outliers in the data set which contribute to the MSWD are identified and eliminated sequentially until the MSWD falls below the cutoff value, based on the criteria of Wendt and Carl (1991). Data are also regressed on an isochron plot. As for step heating data, isochrons are generally preferred for age calculation.

D-48 Sanidine

This sample produced a set of 21 laser fusion ages on single sanidine crystals, 20 of which define a statistically coherent population with one distinctly older outlier. The mean age of all 21 analyses is 39.16 ± 0.30 Ma, and the weighted mean of 20 analyses is indistinguishable at 39.12 ± 0.04 Ma. Seventeen of the analyses define an isochron age of 39.18 ± 0.06 Ma, and suggest a small amount of excess argon is present, as the $^{40}Ar/^{36}Ar$ intercept is 303.4 ± 1.4, slightly higher than the atmospheric value of 295.5. Note that all 3 methods of calculating an age agree within 1σ uncertainty. All of the analyses have consistent Ca/K ratios and high radiogenic yields (%$^{40}Ar^*$), indicating a chemically homogeneous population of crystals that are unaltered. Generally the isochron age is recommended if one is obtained, although in this case either the isochron or the weighted mean age should be reliable. This is because, although a small amount of excess argon is indicated by the isochron, it clearly is not significant since the isochron and the ages calculated based on apparent ages (mean and weighted mean) are not statistically distinguishable.

GC110309-2 Andesite Groundmass

This sample produced a consistent and easily interpreted data set. The age spectrum is characterized by a low-age first step (~22 Ma) followed by ages which decrease from step 2 (27 Ma) to consistent ages of ~26 Ma for the final ~80% ^{39}Ar released. The total gas age, which is equivalent to a conventional K/Ar age, is 25.87 ± 0.13 Ma. Steps 7-11 (53% of the ^{39}Ar released) define an indistinguishable plateau age of 25.77 ± 0.14 Ma. Steps 7-10 (50% of the ^{39}Ar released) define a statistically valid isochron age of 25.86 ± 0.16 Ma, and the initial $^{40}Ar/^{36}Ar$ = 278 ± 31, indistinguishable from the atmospheric value of 295.5. Ca/K ratios are similar (with the exception of the first and last steps) and radiogenic yields are high for this material, indicating a homogeneous sample that has not undergone recent alteration. Note that all of these ages overlap within 1σ analytical uncertainty. Also, note that, although the isochron is valid, it is defined by only 4 points all of which are very close together near the x-axis. For this reason, and the lack of evidence for excess argon, I would recommend using the plateau age for this sample.

HM071809-2 Sanidine

This sample produced a set of 21 laser fusion ages on single sanidine crystals, all of which define a statistically coherent data set. The mean age of all 21 analyses is 35.04 ± 0.23 Ma, and the weighted mean of these same analyses is identical at 35.04 ± 0.05 Ma. Fifteen analyses define a statistically valid isochron, which yields an age of 34.96 ± 0.11 Ma, and an initial $^{40}Ar/^{36}Ar$ = 306 ± 9, indistinguishable from atmospheric argon. All analyses have consistent Ca/K ratios and high radiogenic yields, indicating a chemically homogeneous, unaltered population of analyzed crystals. As for D-48 sanidine discussed above, either the weighted mean or the isochron ages are acceptable for this sample.

HM071809-4 Sanidine

This sample produced an ideal, “textbook” example data set. Eighteen laser fusion ages on single sanidine crystals all define a statistically coherent data set with no outliers, and all three methods of age calculation yield the exact same age. The mean age of all 18 analyses is 33.80 ± 0.14 Ma, and the weighted mean of these same analyses is identical at 33.80 ± 0.05 Ma. All 18 analyses yield a well defined, statistically valid isochron, which yields an age of 33.80 ± 0.08 Ma, and an initial $^{40}Ar/^{36}Ar = 298.5 \pm 3.5$, indistinguishable from atmospheric argon. All analyses have consistent Ca/K ratios and reasonably high radiogenic yields, indicating a chemically homogeneous, unaltered population of analyzed crystals. Given identical ages via all three calculation methods, and no evidence for excess argon, either the weighted mean or isochron ages are acceptable.

RV-24 Biotite

This sample also produced a consistent and easily interpreted data set. The age spectrum is generally flat and concordant (with the exception of slightly younger ages in the first 2 steps, which comprise <4% of the gas released). The total gas age is 32.37 ± 0.18 Ma. Steps 7-12 (69% of the ^{39}Ar released) define an indistinguishable plateau age of 32.34 ± 0.19 Ma. The same steps yield an isochron age of 32.38 ± 0.10 Ma, and an initial $^{40}Ar/^{36}Ar = 293.2 \pm 2.3$, thus indicating no excess argon is present in the sample. Ca/K ratios are somewhat variable, with values generally consistent with outgassing of biotite, except for the first two and last two steps (combined <6% of the gas released). This suggests some relatively minor higher Ca phases degassing early and late in the step heating run. Radiogenic yields are correlated, with more consistently high yields for the low Ca/K steps, corresponding to biotite outgassing. The isochron age should be considered the most reliable for this sample.

RV-30 Sanidine

This sample produced a set of 26 laser fusion ages on single sanidine crystals, 18 of which define a statistically coherent data set, with both younger and older outliers. The mean age of all analyses is 40.3 ± 2.3 Ma. Eighteen of these yield a concordant population, with a slightly older, but statistically indistinguishable, weighted mean age of 41.06 ± 0.21 Ma. There is no isochron age defined by these data. Note that Ca/K ratios and radiogenic yields are distinctly more variable for these analyses when compared to the laser fusion data sets discussed above. There is no clear correlation between age and Ca/K ratio. However, there is a rough correlation between age and radiogenic yield, in which lower $\%^{40}Ar^*$ is broadly related to younger ages. This may indicate some alteration and loss of radiogenic argon from the younger age crystals. One analysis is distinctly older, and may represent a xenocryst. The weighted mean age should be considered the most reliable for this sample.

The interpretations given above are based simply on inspection of the laboratory data. Geologic relationships, which are unknown to us, are not considered. Please feel free to call or email (best way to contact me terry.spell@unlv.edu) if you have questions.

REFERENCES

Renne, P.R., Swisher, C.C, Deino, A.L., Karner, D.B., Owens, T.L., DePaolo, D.J., 1998, Intercalibration of standards, absolute ages and uncertainties in $^{40}Ar/^{39}Ar$ dating, *Chemical Geology*, v. 145, p. 117-152.

Staudacher, T.H., Jessberger, E.K., Dorflinger, D., and Kiko, J., A refined ultrahigh-vacuum furnace for rare gas analysis, *J. Phys. E: Sci. Instrum.*, *11*, 781-784, 1978.

Wendt, I., and Carl, C., 1991, The statistical distribution of the mean squared weighted deviation, *Chemical Geology*, v. 86, p. 275-285.

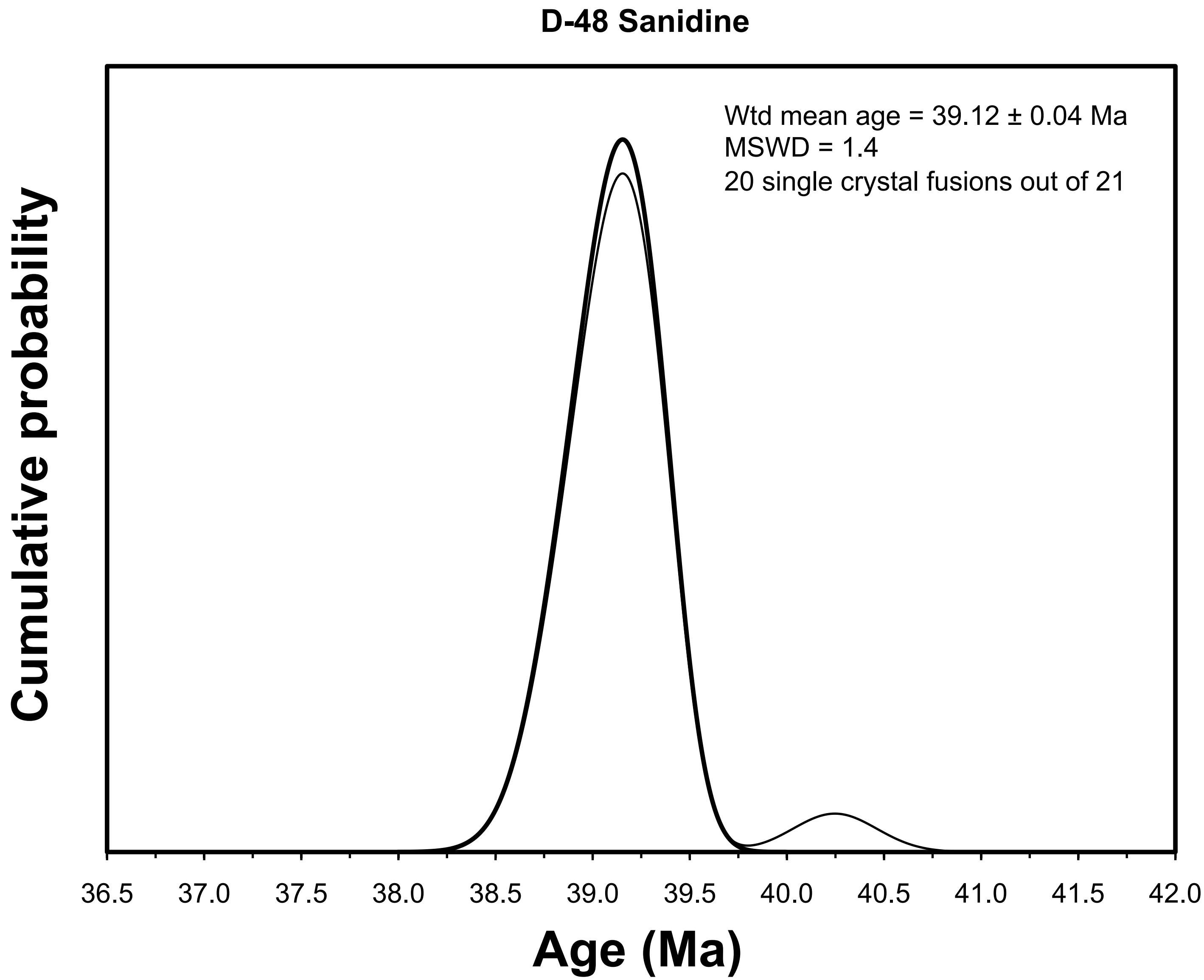
APPENDIX

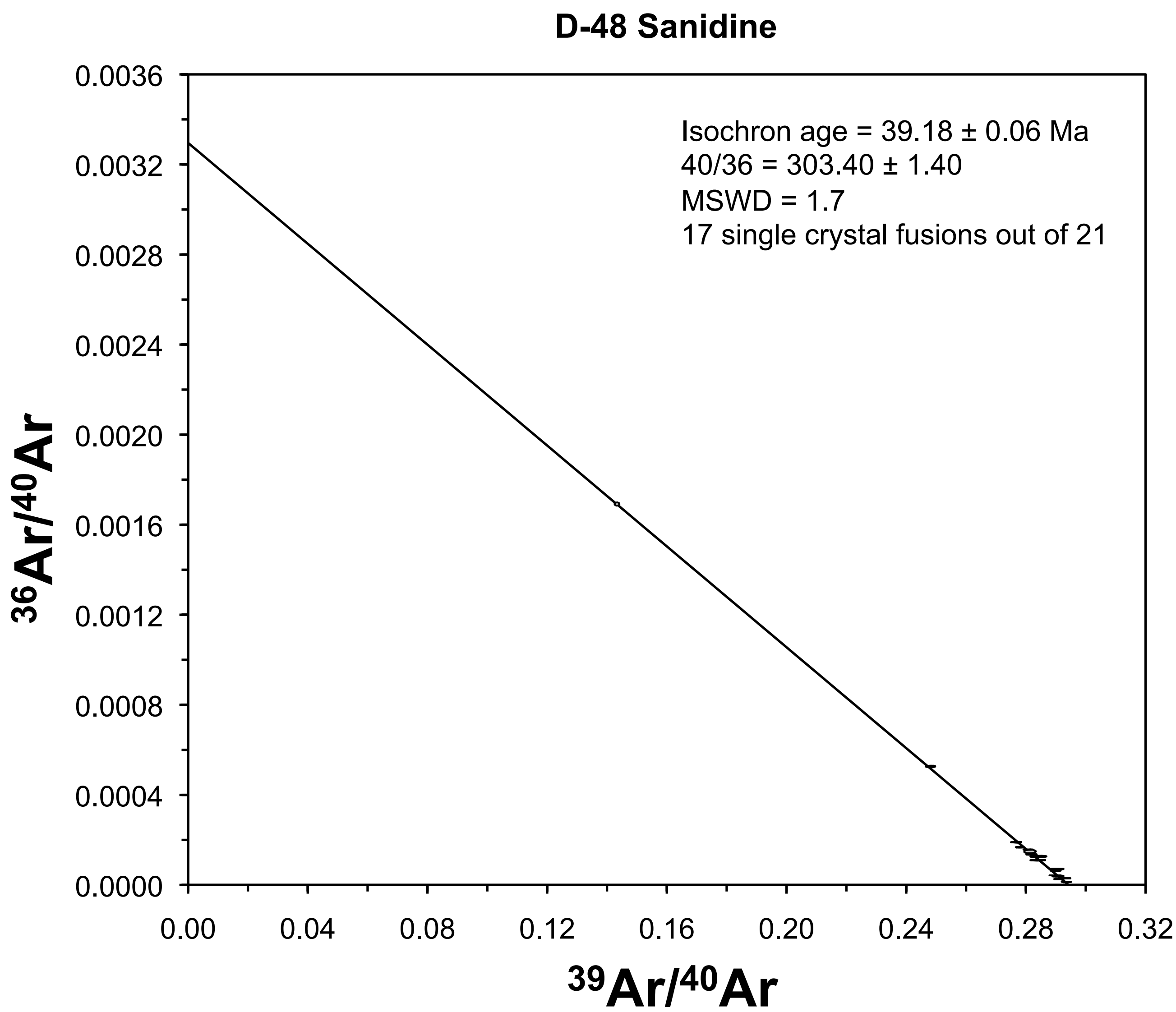
Analytical data for samples D-48 sanidine, GC110309-2 andesite groundmass, HM071809-2 sanidine, HM071809-4 sanidine, RV-24 biotite, RV-30 sanidine

Biek-UT DNR, D-48, Sanidine, Single Crystal Fusions, J = 0.00646 ± 0.21%
4 amu discrimination = 1.0578 ± 0.23%, 40/39K = 0.00642 ± 24.60%, 36/37Ca = 0.0002565 ± 3.19%, 39/37Ca = 0.0006497 ± 1.42%

Crystal	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	1600	2	0.239	3.129	21.463	1585.08	5352.21	98.7	0.01284	3.37450	38.91	0.15
2	1600	2	0.274	1.101	7.212	520.889	1803.74	95.9	0.01375	3.35766	38.71	0.19
3	1600	2	0.229	1.871	10.453	765.192	2612.34	97.6	0.01591	3.37152	38.87	0.17
4	1600	2	0.683	2.047	13.919	1023.01	3642.82	94.7	0.01302	3.41553	39.37	0.15
5	1600	2	0.143	1.378	10.038	739.514	2530.02	98.4	0.01212	3.40878	39.30	0.15
6	1600	2	2.465	2.248	15.282	1092.49	4360.09	84.2	0.01339	3.40159	39.21	0.15
7	1600	2	0.144	1.654	10.228	747.486	2547.08	98.4	0.01440	3.39519	39.14	0.15
8	1600	2	0.323	1.386	9.672	707.836	2475.86	96.4	0.01274	3.41203	39.33	0.15
9	1600	2	1.696	1.958	13.101	935.826	3599.48	86.8	0.01361	3.38098	38.98	0.16
10	1600	2	0.067	1.272	1.000	737.655	2489.37	99.3	0.01122	3.39063	39.09	0.15
11	1600	2	0.116	1.631	11.062	818.912	2770.32	98.8	0.01296	3.38440	39.02	0.16
12	1600	2	0.284	2.147	14.834	1093.13	3733.76	97.8	0.01278	3.38370	39.01	0.14
13	1600	2	0.443	6.127	15.071	730.675	2572.99	95.2	0.05456	3.39466	39.14	0.16
14	1600	2	0.203	3.784	23.100	1704.36	5802.25	98.9	0.01445	3.41159	39.33	0.14
15	1600	2	0.255	0.954	6.700	490.236	1709.96	95.9	0.01266	3.38511	39.03	0.20
16	1600	2	7.873	1.425	10.090	634.779	4388.33	49.9	0.01461	3.49220	40.25	0.22
17	1600	2	0.351	1.240	8.655	638.434	2245.77	95.7	0.01264	3.40598	39.26	0.15
18	1600	2	0.685	2.124	12.446	904.205	3234.99	94.1	0.01528	3.40738	39.28	0.15
19	1600	2	0.281	1.634	8.507	622.436	2166.60	96.4	0.01708	3.39668	39.16	0.14
20	1600	2	0.318	1.072	6.693	490.800	1734.12	95.0	0.01421	3.39475	39.14	0.15
21	1600	2	0.133	1.199	8.110	590.752	2000.04	98.2	0.01321	3.36424	38.79	0.15
										Mean ± s.d. =	39.16	0.30
										Wtd mean age =	39.12	0.04
										(20 single crystal fusions)		
										Isochron age =	39.18	0.06
										(17 single crystal fusions)		

note: isotope beams in mV rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay in age calculations)


D-48 Sanidine
Wtd mean age = 39.12 ± 0.04 Ma
MSWD = 1.4
20 single crystal fusions out of 21
Cumulative probability
36.5
37.0
37.5
38.0
38.5
39.0
39.5
40.0
40.5
41.0
41.5
42.0
Age (Ma)


D-48 Sanidine
Isochron age = 39.18 ± 0.06 Ma
40/36 = 303.40 ± 1.40
MSWD = 1.7
17 single crystal fusions out of 21
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
36Ar/40Ar
39Ar/40Ar

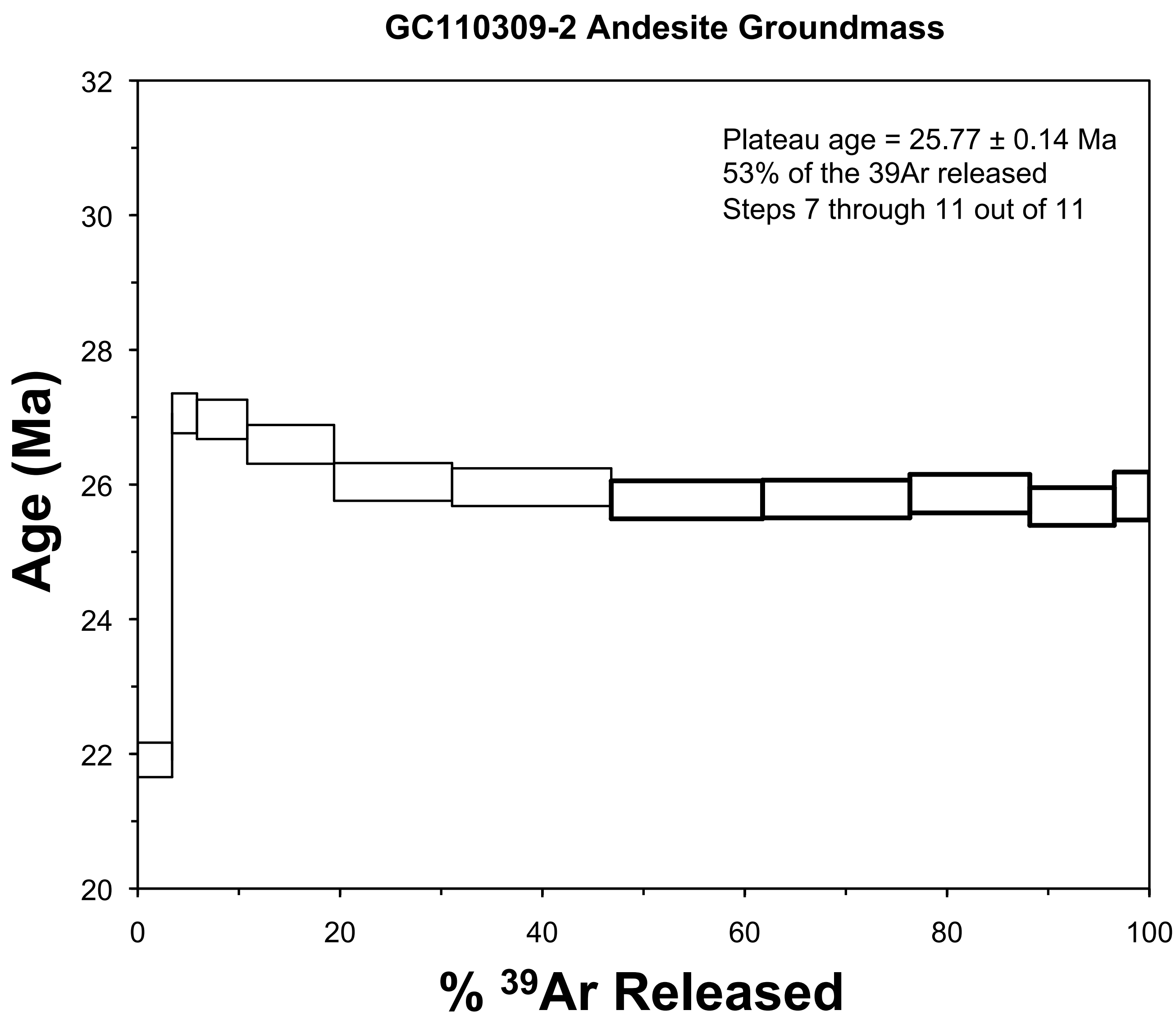
Biek-UT DNR, GC110309-2, Andesite Groundmass, 28.27 mg, J = 0.00649 ± 0.50%

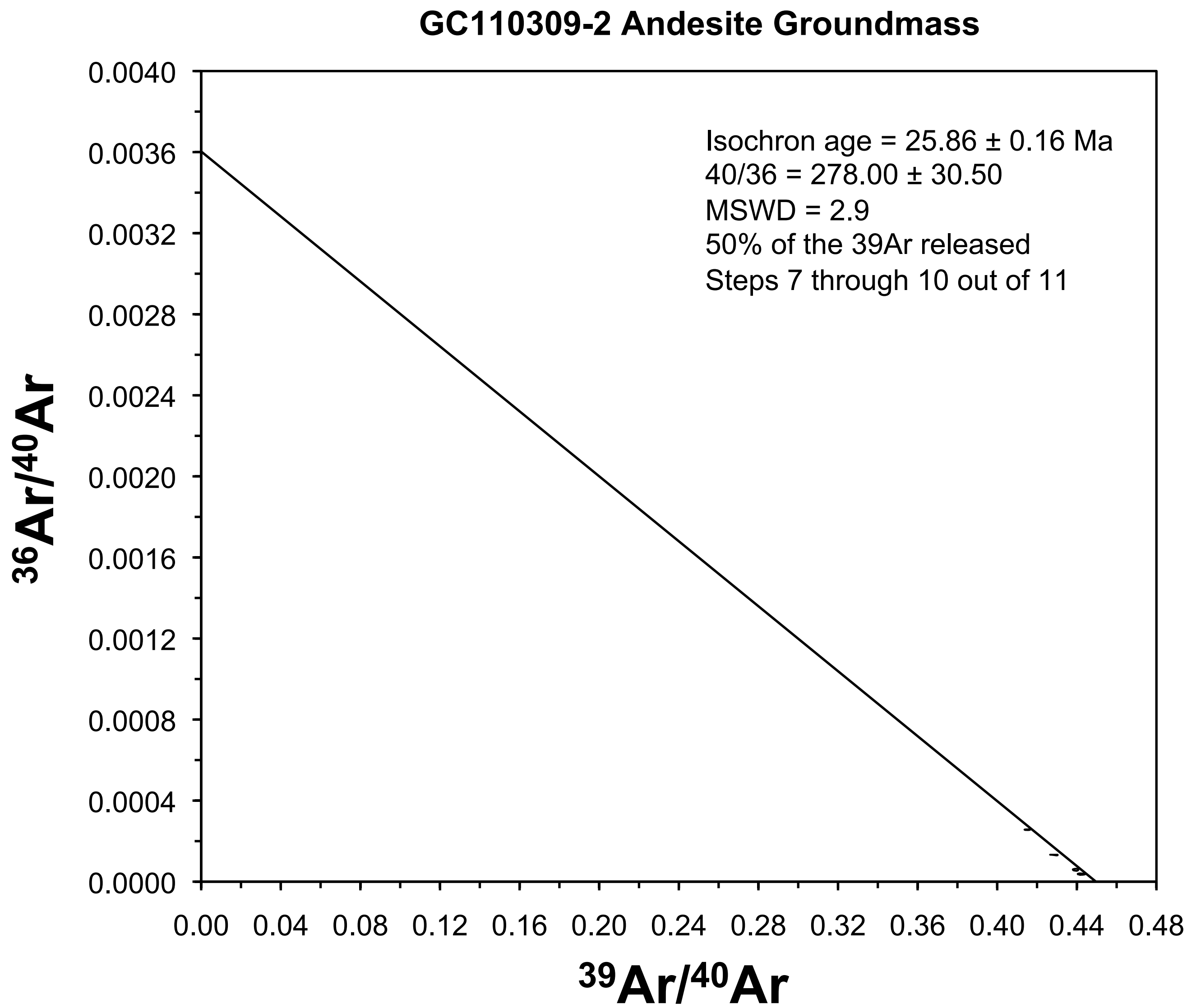
4 amu discrimination = 1.0458 ± 0.14%, 40/39K = 0.00642 ± 24.60%, 36/37Ca = 0.0002565 ± 3.19%, 39/37Ca = 0.0006497 ± 1.42%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	1.058	28.317	4.550	248.983	757.29	61.4	3.4	0.803284774	1.882792	21.91	0.13
2	650	12	0.116	29.234	2.645	179.648	440.53	94.4	2.5	1.14947705	2.328396	27.06	0.15
3	700	12	0.152	57.965	4.965	363.636	866.22	96.6	5.0	1.125979634	2.320593	26.97	0.15
4	750	12	0.178	95.997	8.502	628.106	1453.05	98.0	8.6	1.07956947	2.288433	26.60	0.14
5	800	12	0.265	121.798	11.622	853.442	1942.36	97.5	11.7	1.008052728	2.240074	26.04	0.14
6	850	12	0.262	158.237	15.935	1151.236	2587.19	98.4	15.7	0.970859135	2.233316	25.96	0.14
7	900	12	0.292	148.448	15.461	1094.417	2454.40	97.9	15.0	0.958081592	2.217027	25.77	0.14
8	970	12	0.353	161.555	16.295	1065.380	2406.41	97.2	14.6	1.071126351	2.218067	25.79	0.14
9	1060	12	0.455	148.115	15.906	867.261	2008.23	95.2	11.9	1.20639813	2.224998	25.87	0.14
10	1160	12	0.527	105.786	12.145	611.240	1463.63	91.5	8.4	1.222530877	2.208450	25.67	0.14
11	1400	12	0.807	280.641	9.562	253.724	721.00	78.0	3.5	7.827846036	2.221966	25.83	0.18
							Cumulative %39Ar rlsd =		100.0		Total gas age =	25.87	0.13
											Plateau age = (steps 7-11)	25.77	0.14
											Isocrhon age = (steps 7-10)	25.86	0.16

note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma

(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)

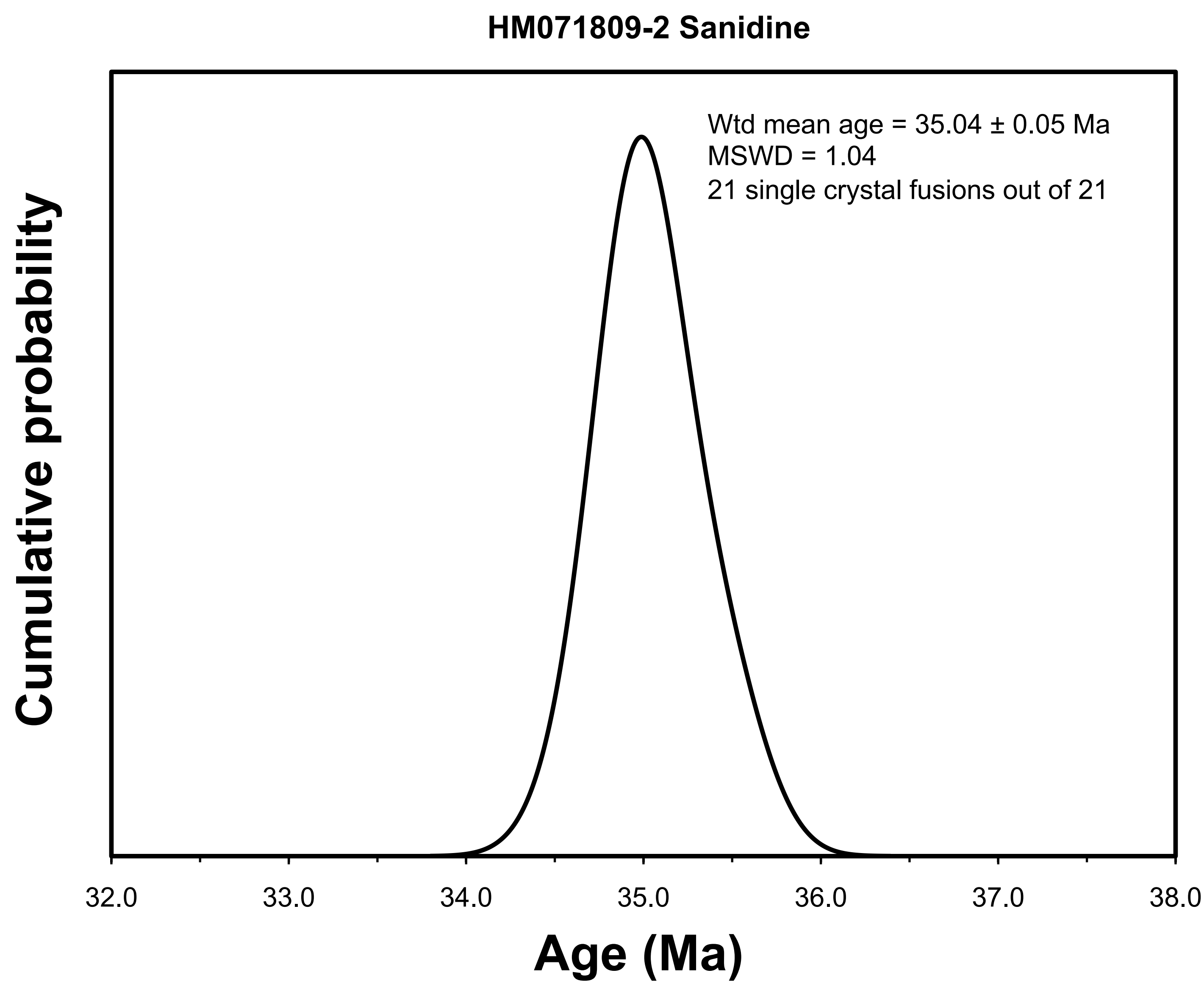

GC110309-2 Andesite Groundmass
Plateau age = 25.77 ± 0.14 Ma
53% of the 39Ar released
Steps 7 through 11 out of 11
Age (Ma)
% 39Ar Released
32
30
28
26
24
22
20
0
20
40
60
80
100


GC110309-2 Andesite Groundmass
Isochron age = 25.86 ± 0.16 Ma
40/36 = 278.00 ± 30.50
MSWD = 2.9
50% of the 39Ar released
Steps 7 through 10 out of 11
0.0040
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
36Ar/40Ar
39Ar/40Ar

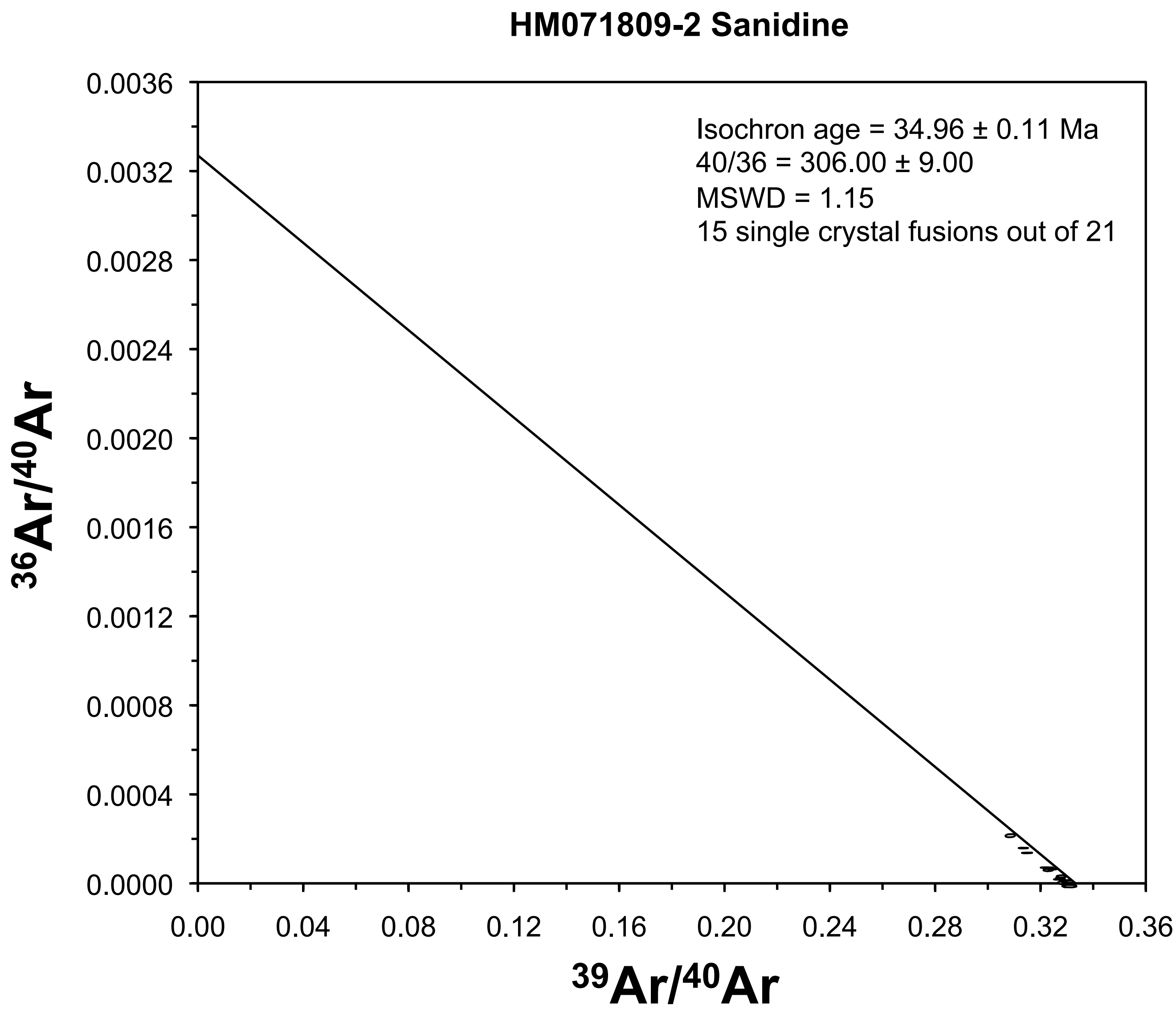
Biek-UT DNR, HM071809-2, Sanidine, Single Crystal Fusions, J = 0.006523 ± 0.57%
4 amu discrimination = 1.0578 ± 0.23%, 40/39K = 0.00642 ± 24.60%, 36/37Ca = 0.0002565 ± 3.19%, 39/37Ca = 0.0006497 ± 1.42%

Crystal	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	1600	2	0.092	0.897	6.497	478.938	1443.59	98.3	0.01242	2.99697	34.93	0.22
2	1600	2	0.077	0.950	6.600	491.216	1472.43	98.6	0.01282	2.99004	34.85	0.23
3	1600	2	0.437	1.373	9.370	686.667	2159.91	94.4	0.01326	3.00355	35.00	0.23
4	1600	2	0.125	1.816	11.091	812.891	2450.28	98.6	0.01481	3.00693	35.04	0.23
5	1600	2	0.170	1.030	6.737	495.365	1517.20	97.0	0.01379	3.00338	35.00	0.23
6	1600	2	0.142	1.028	6.336	451.200	1379.41	97.2	0.01511	3.00607	35.03	0.23
7	1600	2	0.112	3.785	4.314	318.793	971.06	97.1	0.07872	2.98735	34.82	0.23
8	1600	2	0.435	1.248	7.251	519.135	1660.98	92.8	0.01594	3.00191	34.99	0.23
9	1600	2	0.098	0.817	5.432	397.766	1221.21	97.9	0.01362	3.03891	35.41	0.23
10	1600	2	0.045	0.530	3.321	243.831	739.231	98.7	0.01441	3.01932	35.19	0.24
11	1600	2	0.048	0.752	5.247	387.152	1159.48	99.0	0.01288	2.99731	34.93	0.22
12	1600	2	0.044	0.624	4.051	300.272	904.504	98.9	0.01378	3.00944	35.07	0.23
13	1600	2	0.249	0.936	5.975	437.877	1373.06	95.1	0.01417	3.01386	35.12	0.23
14	1600	2	0.056	1.361	9.691	716.364	2174.89	99.3	0.01260	3.05052	35.55	0.23
15	1600	2	0.049	0.756	5.030	369.883	1106.41	99.0	0.01355	2.99134	34.86	0.23
16	1600	2	0.037	1.141	7.755	573.328	1712.24	99.5	0.01319	3.00459	35.02	0.22
17	1600	2	0.032	0.657	4.601	339.771	1014.55	99.4	0.01282	2.99714	34.93	0.24
18	1600	2	0.081	0.764	5.388	394.257	1205.36	98.3	0.01285	3.03743	35.40	0.23
19	1600	2	0.075	0.817	4.472	328.415	989.787	98.1	0.01649	2.98761	34.82	0.22
20	1600	2	0.073	0.687	4.187	303.736	909.887	98.0	0.01500	2.96604	34.57	0.22
21	1600	2	0.070	0.603	4.508	330.683	1011.07	98.3	0.01209	3.03648	35.38	0.25
										Mean ± s.d. =	35.04	0.23
										Wtd mean age =	35.04	0.05
										(21 single crystal fusions)		
										Isochron age =	34.96	0.11
										(15 single crystal fusions)		

note: isotope beams in mV rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay in age calculations)



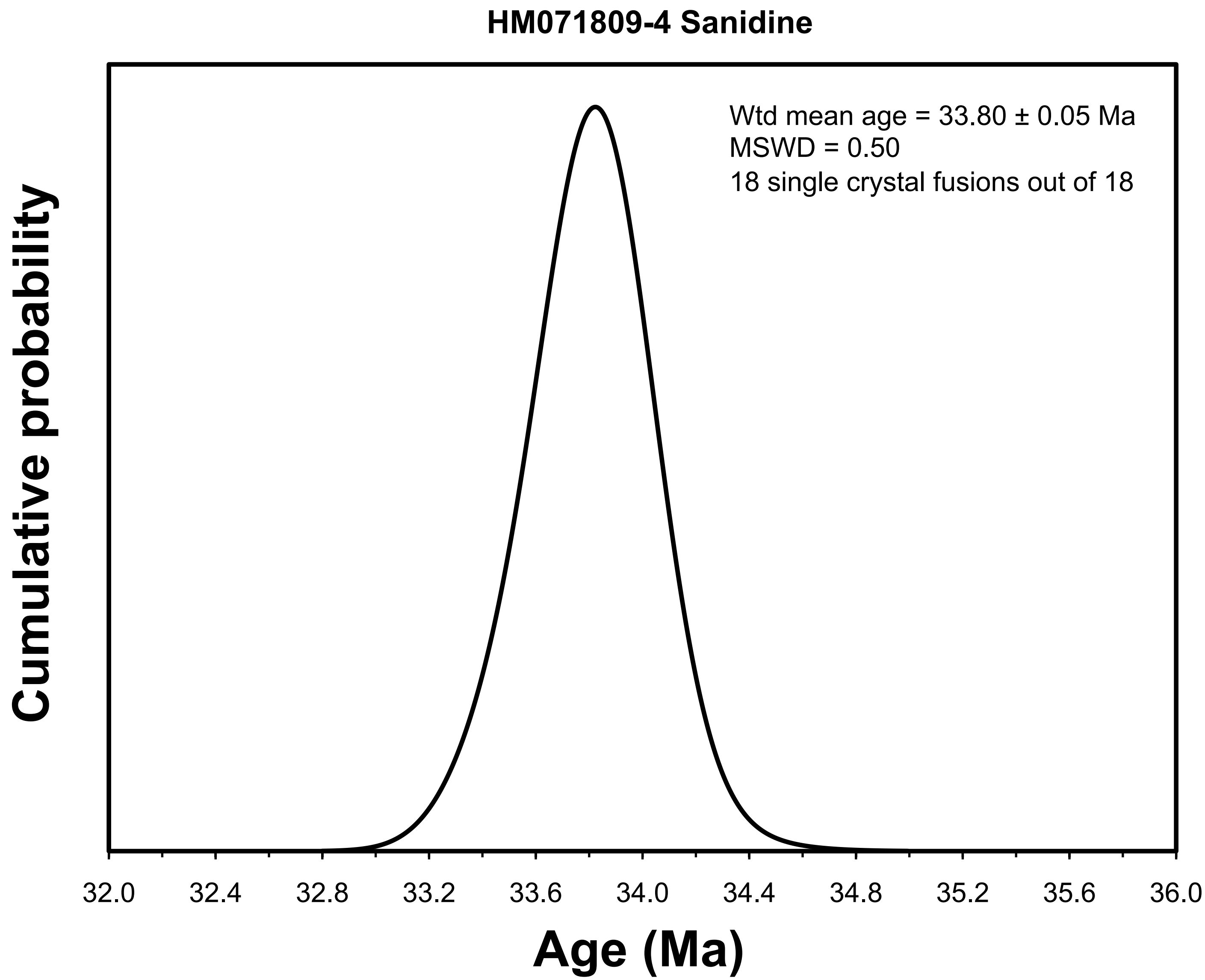
HM071809-2 Sanidine
Wtd mean age = 35.04 ± 0.05 Ma
MSWD = 1.04
21 single crystal fusions out of 21
Cumulative probability
32.0
33.0
34.0
35.0
36.0
37.0
38.0
Age (Ma)

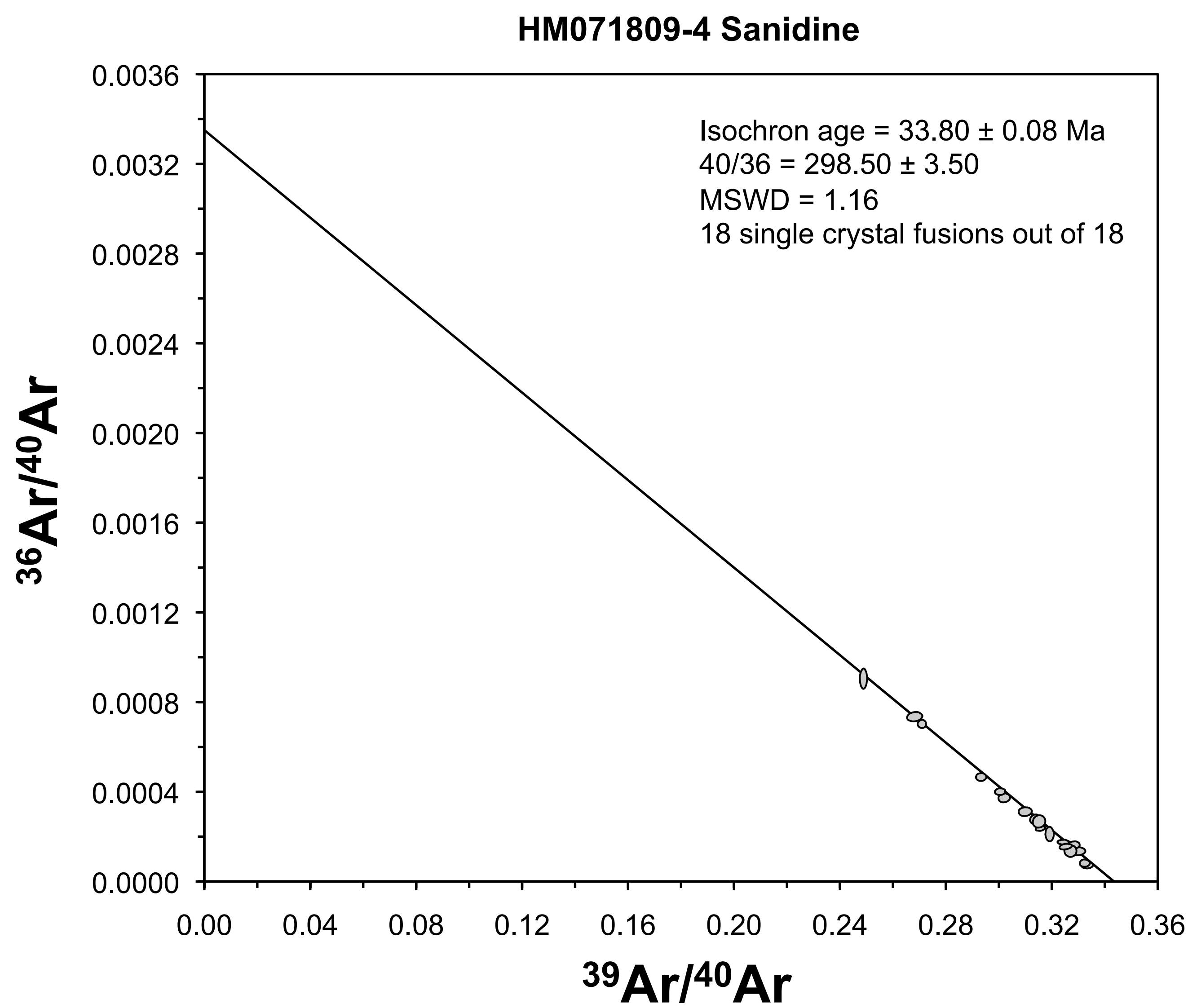

HM071809-2 Sanidine
Isochron age = 34.96 ± 0.11 Ma
40/36 = 306.00 ± 9.00
MSWD = 1.15
15 single crystal fusions out of 21
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
36Ar/40Ar
39Ar/40Ar

Biek-UT DNR, HM071809-4, Sanidine, Single Crystal Fusions, J = 0.006495 ± 0.38%
4 amu discrimination = 1.0578 ± 0.23%, 40/39K = 0.00642 ± 24.60%, 36/37Ca = 0.0002565 ± 3.19%, 39/37Ca = 0.0006497 ± 1.42%

Crystal	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	1600	2	0.076	0.147	0.626	45.612	152.376	88.2	0.02182	2.92673	33.97	0.20
2	1600	2	0.078	0.228	1.028	75.076	238.238	92.2	0.02057	2.92734	33.98	0.17
3	1600	2	0.063	0.200	0.707	49.486	159.048	91.0	0.02737	2.90829	33.76	0.20
4	1600	2	0.051	0.244	1.005	73.774	224.423	95.1	0.02240	2.89299	33.58	0.21
5	1600	2	0.074	0.280	1.289	95.015	292.776	94.0	0.01996	2.90551	33.73	0.17
6	1600	2	0.057	0.190	0.621	44.845	143.731	91.3	0.02869	2.90160	33.68	0.22
7	1600	2	0.117	0.094	0.382	26.715	109.239	72.7	0.02383	2.93012	34.01	0.31
8	1600	2	0.069	0.128	0.689	49.053	159.749	90.0	0.01767	2.91360	33.82	0.21
9	1600	2	0.228	0.248	1.081	77.284	285.153	78.7	0.02173	2.90942	33.77	0.19
10	1600	2	0.130	0.206	1.124	79.533	264.774	87.4	0.01754	2.91603	33.85	0.19
11	1600	2	0.145	0.227	1.055	75.950	259.078	85.5	0.02024	2.92203	33.92	0.19
12	1600	2	0.065	0.315	1.195	86.762	264.433	94.4	0.02459	2.88082	33.44	0.18
13	1600	2	0.232	0.190	1.064	74.672	278.404	77.7	0.01723	2.90455	33.72	0.24
14	1600	2	0.036	0.117	0.589	43.234	133.856	95.1	0.01833	2.91568	33.85	0.20
15	1600	2	0.039	0.268	1.115	82.437	247.730	97.0	0.02201	2.91612	33.85	0.18
16	1600	2	0.058	0.244	1.062	77.519	238.776	94.6	0.02131	2.91499	33.84	0.18
17	1600	2	0.048	0.165	0.596	44.687	141.527	93.0	0.02500	2.91881	33.88	0.21
18	1600	2	0.034	0.218	0.795	59.899	181.196	96.7	0.02465	2.91342	33.82	0.18
										Mean ± s.d. =	33.80	0.14
										Wtd mean age =	33.80	0.05
										(18 single crystal fusions)		
										Isochron age =	33.80	0.08
										(18 single crystal fusions)		

note: isotope beams in mV rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay in age calculations)

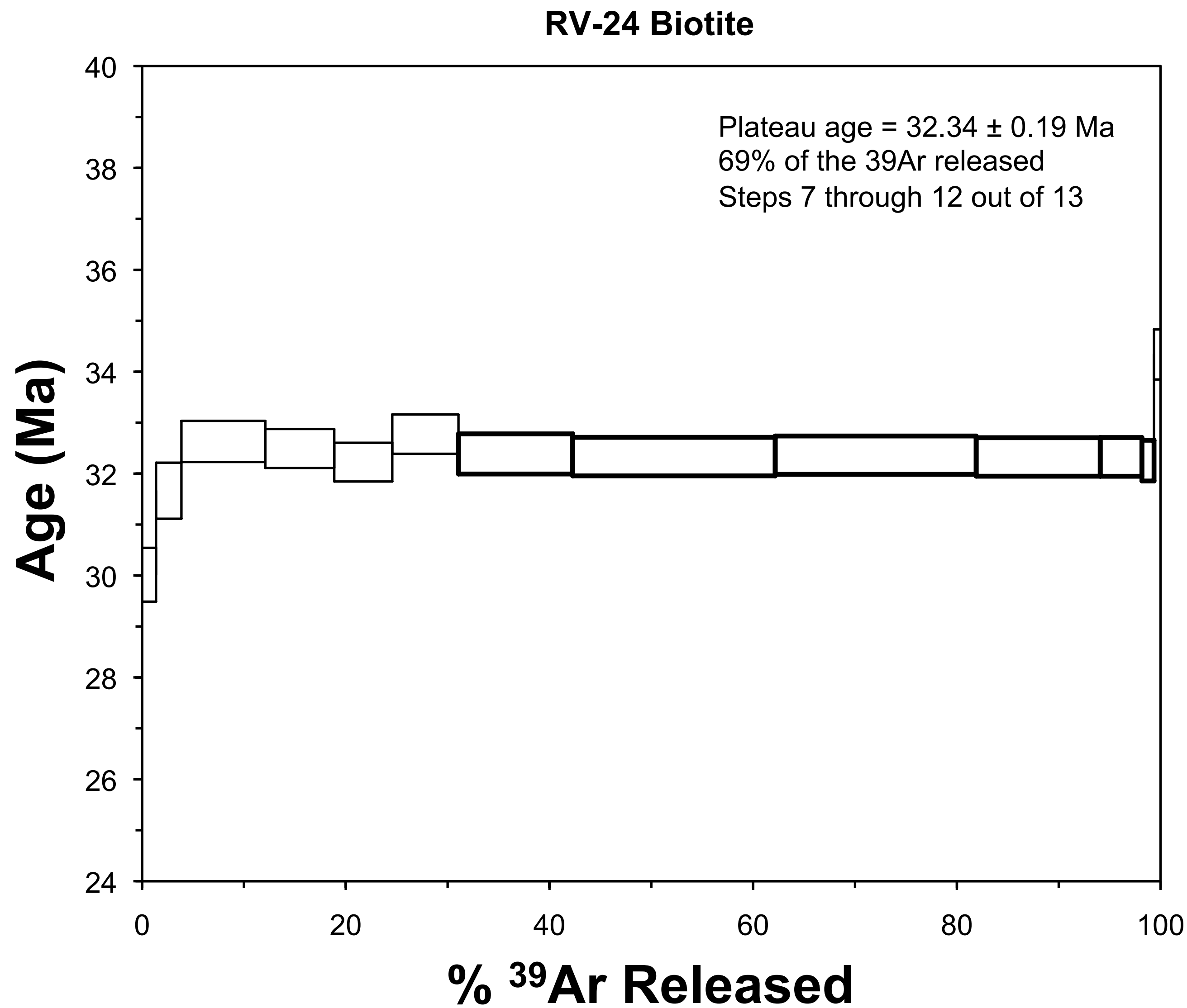

HM071809-4 Sanidine
Wtd mean age = 33.80 ± 0.05 Ma
MSWD = 0.50
18 single crystal fusions out of 18
Cumulative probability
32.0
32.4
32.8
33.2
33.6
34.0
34.4
34.8
35.2
35.6
36.0
Age (Ma)

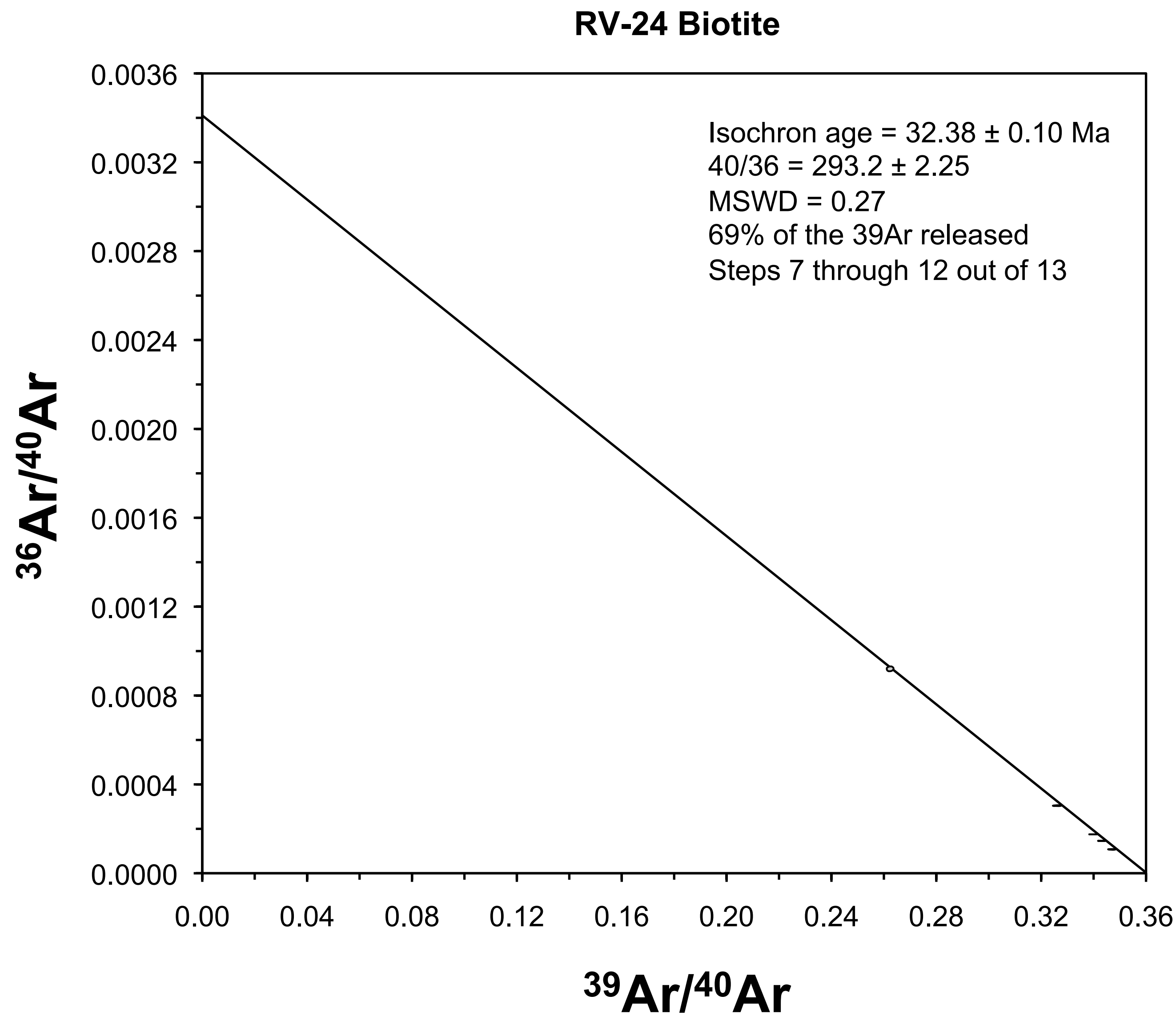

HM071809-4 Sanidine
Isochron age = 33.80 ± 0.08 Ma
40/36 = 298.50 ± 3.50
MSWD = 1.16
18 single crystal fusions out of 18
36Ar/40Ar
39Ar/40Ar
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36

Biek-UT DNR, RV-24, Biotite, 12.18 mg, J = 0.006526 ± 0.55%
4 amu discrimination = 1.0458 ± 0.14%, 40/39K = 0.00642 ± 24.60%, 36/37Ca = 0.0002565 ± 3.19%, 39/37Ca = 0.0006497 ± 1.42%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	650	12	3.099	6.348	4.242	97.540	1122.36	22.1	1.4	0.443743961	2.570715	30.02	0.26
2	725	12	4.035	31.559	7.172	177.094	1608.87	29.6	2.5	1.215324657	2.713191	31.66	0.28
3	790	12	4.247	11.652	22.017	585.623	2820.56	57.5	8.2	0.135650952	2.796889	32.63	0.20
4	850	12	0.857	2.039	17.162	481.000	1569.17	84.6	6.8	0.028900114	2.784954	32.49	0.19
5	905	12	0.530	2.262	14.195	404.817	1257.01	88.2	5.7	0.03809451	2.761692	32.23	0.19
6	960	12	0.638	9.483	16.148	461.889	1464.52	87.8	6.5	0.139974575	2.809257	32.78	0.19
7	1015	12	0.849	18.163	27.988	797.452	2430.45	90.2	11.2	0.155283723	2.775614	32.39	0.20
8	1055	12	0.740	17.273	49.152	1412.865	4086.43	94.8	19.9	0.083349152	2.771117	32.33	0.19
9	1095	12	0.855	12.922	47.886	1402.403	4095.69	94.0	19.7	0.062818631	2.773539	32.36	0.19
10	1130	12	0.358	8.553	29.212	865.668	2477.78	95.9	12.2	0.067359558	2.770512	32.33	0.19
11	1160	12	0.320	8.654	10.113	291.218	888.652	90.2	4.1	0.202603706	2.770599	32.33	0.19
12	1190	12	0.332	9.247	3.469	84.362	323.000	72.3	1.2	0.747428285	2.764286	32.26	0.20
13	1400	12	0.823	18.595	2.726	45.716	361.284	37.6	0.6	2.775186256	2.944593	34.34	0.25
							Cumulative %39Ar rlsd =		100.0		Total gas age =	32.37	0.18
											Plateau age = (steps 7-12)	32.34	0.19
											Isocrhon age = (steps 7-12)	32.38	0.10

note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)


RV-24 Biotite
Plateau age = 32.34 ± 0.19 Ma
69% of the 39Ar released
Steps 7 through 12 out of 13
Age (Ma)
% 39Ar Released
40
38
36
34
32
30
28
26
24
0
20
40
60
80
100

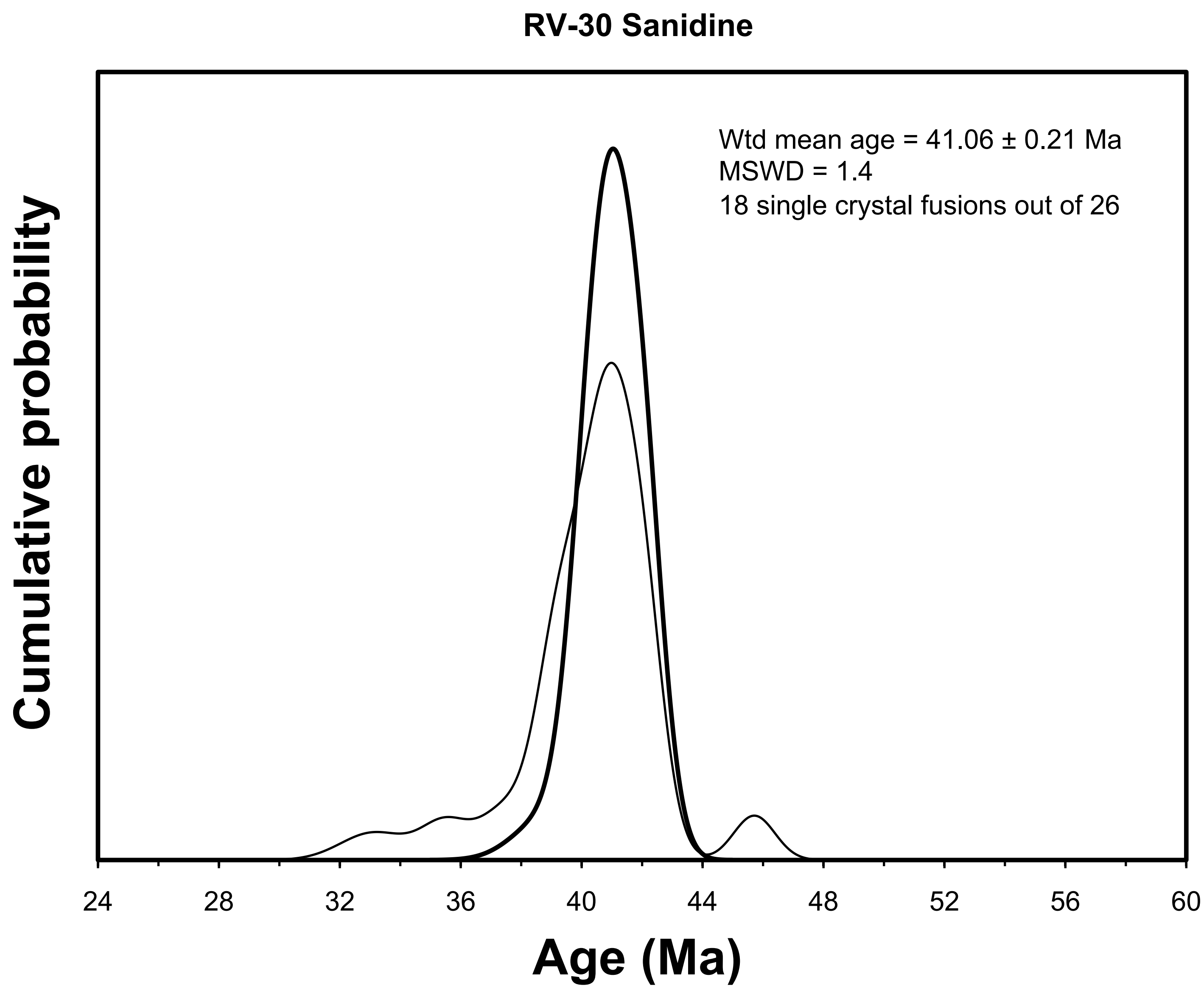

RV-24 Biotite
Isochron age = 32.38 ± 0.10 Ma
40/36 = 293.2 ± 2.25
MSWD = 0.27
69% of the 39Ar released
Steps 7 through 12 out of 13
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
36Ar/40Ar
39Ar/40Ar

Biek-UT DNR, RV-30, Sanidine, Single Crystal Fusions, J = 0.006457 ± 0.48%
4 amu discrimination = 1.0476 ± 0.91%, 40/39K = 0.00642 ± 24.60%, 36/37Ca = 0.0002565 ± 3.19%, 39/37Ca = 0.0006497 ± 1.42%

Crystal	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	1600	2	0.059	0.106	0.150	8.763	45.948	71.0	0.21371	3.51788	40.52	0.68
2	1600	2	0.112	0.311	0.411	17.125	92.551	69.5	0.32086	3.67186	42.27	0.67
3	1600	2	0.150	0.342	0.612	25.356	128.822	69.7	0.23830	3.49725	40.29	0.65
4	1600	2	0.231	0.667	0.827	34.322	184.090	66.4	0.34336	3.54185	40.79	0.71
5	1600	2	0.113	0.136	0.273	11.542	69.323	58.3	0.20818	3.38422	39.00	0.72
6	1600	2	0.166	0.379	0.717	29.897	153.296	71.7	0.22397	3.64066	41.92	0.65
7	1600	2	0.171	0.282	0.530	23.844	130.781	65.5	0.20895	3.55019	40.89	0.69
8	1600	2	0.134	0.251	0.522	19.737	103.092	66.4	0.22469	3.40563	39.24	0.65
9	1600	2	0.126	0.296	0.411	17.881	94.335	65.7	0.29248	3.39352	39.10	0.70
10	1600	2	0.129	0.237	0.600	22.927	115.493	71.4	0.18263	3.53948	40.77	0.63
11	1600	2	0.086	0.097	0.346	12.470	64.660	67.4	0.13743	3.36949	38.83	1.07
12	1600	2	0.103	0.391	0.512	21.789	106.626	76.1	0.31705	3.65709	42.11	0.63
13	1600	2	0.104	0.413	0.541	19.119	103.214	75.0	0.38167	3.97410	45.71	0.68
14	1600	2	0.101	0.308	0.374	14.939	69.648	63.7	0.36427	2.86988	33.13	1.10
15	1600	2	0.102	0.087	0.282	13.489	73.083	64.9	0.11395	3.40721	39.26	0.69
16	1600	2	0.089	0.333	0.372	15.260	78.075	72.3	0.38556	3.59278	41.37	0.65
17	1600	2	0.135	0.356	0.496	17.401	99.287	64.9	0.36147	3.62942	41.79	0.70
18	1600	2	0.096	0.329	0.450	20.134	94.643	75.1	0.28871	3.45406	39.79	0.63
19	1600	2	0.085	0.149	0.333	14.056	72.518	71.6	0.18728	3.57592	41.18	0.77
20	1600	2	0.111	0.250	0.634	21.621	105.998	73.7	0.20429	3.54738	40.86	0.67
21	1600	2	0.150	0.300	0.680	29.929	143.107	73.6	0.17709	3.48627	40.16	0.63
22	1600	2	0.135	0.211	0.319	14.059	85.443	60.4	0.26516	3.58374	41.27	0.75
23	1600	2	0.153	0.353	0.598	18.144	106.309	63.5	0.34374	3.65929	42.13	0.72
24	1600	2	0.265	0.452	0.579	24.505	146.824	51.8	0.32589	3.07820	35.51	0.80
25	1600	2	0.232	0.474	0.888	31.696	175.103	65.1	0.26422	3.57750	41.20	0.69
26	1600	2	0.154	0.215	0.262	12.731	81.751	51.7	0.29838	3.23981	37.35	0.78
										Mean ± s.d. =	40.25	2.32
										Wtd mean age =	41.06	0.21

note: isotope beams in mV rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay in age calculations)

(18 single crystal fusions)
No isochron


RV-30 Sanidine
Wtd mean age = 41.06 ± 0.21 Ma
MSWD = 1.4
18 single crystal fusions out of 26
Cumulative probability
24
28
32
36
40
44
48
52
56
60
Age (Ma)